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DEVELOPMENT OF ROBOTIC INSPECTION TOOLS FOR APPLICATIONS IN HIGH-LEVEL WASTE PROCESSING

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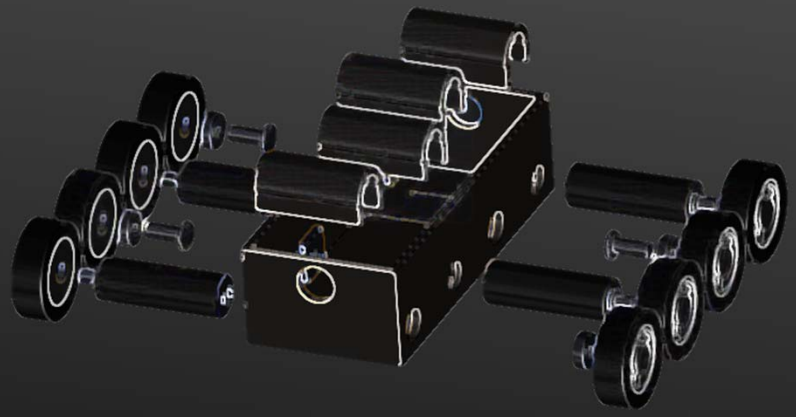
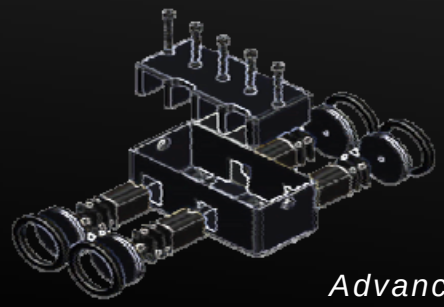
OUTLINE

- Background
- Tank Inspections
- Peristaltic Crawler
  - Testing and Evaluation
- Magnetic Miniature Rover
  - Testing and Evaluation
- Pipe External Crawler
- Path Forward





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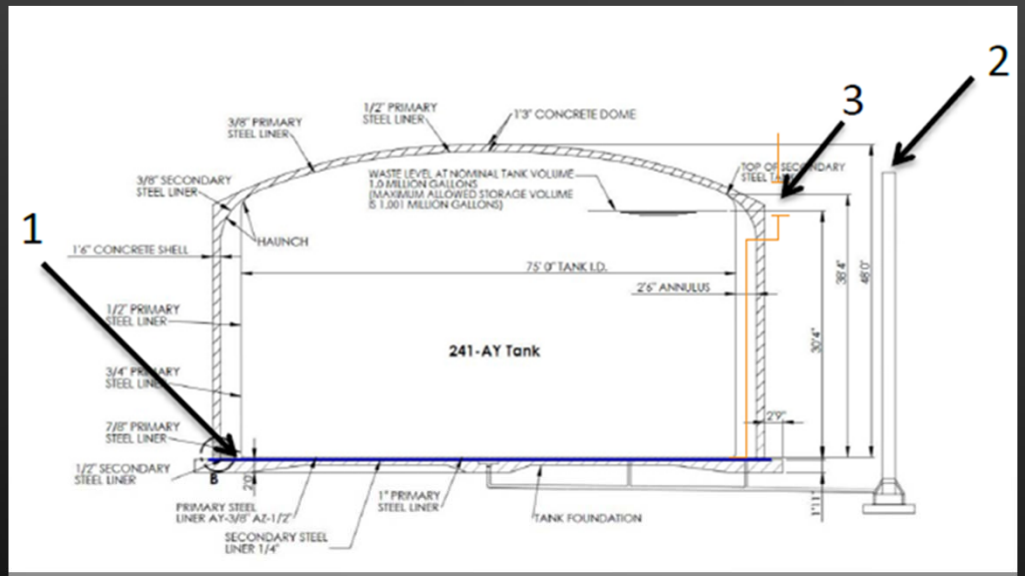
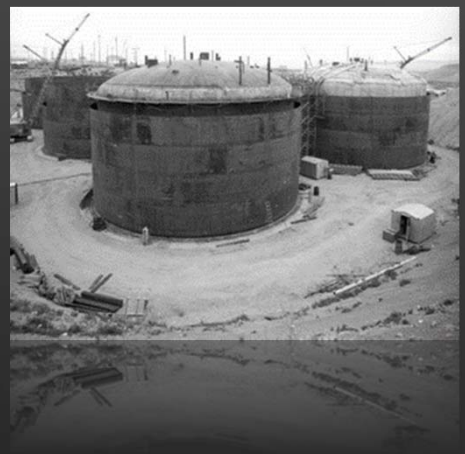
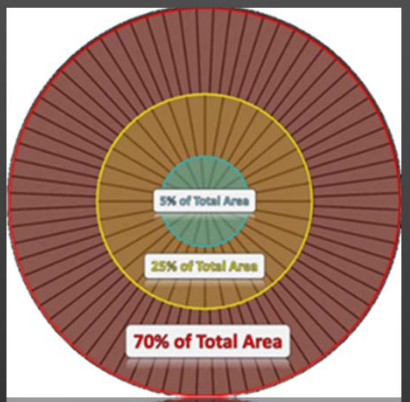
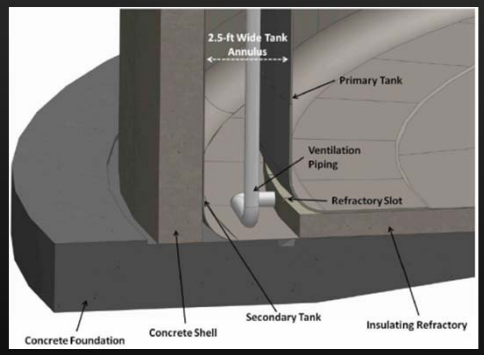
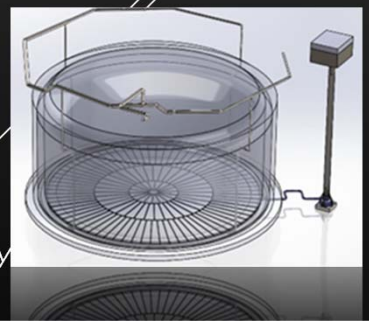
TASK DESCRIPTION











1.) Refractory Air Slots through the Annulus

2.) 6" Leak Detection Piping

3.) 4" Air Supplying Piping

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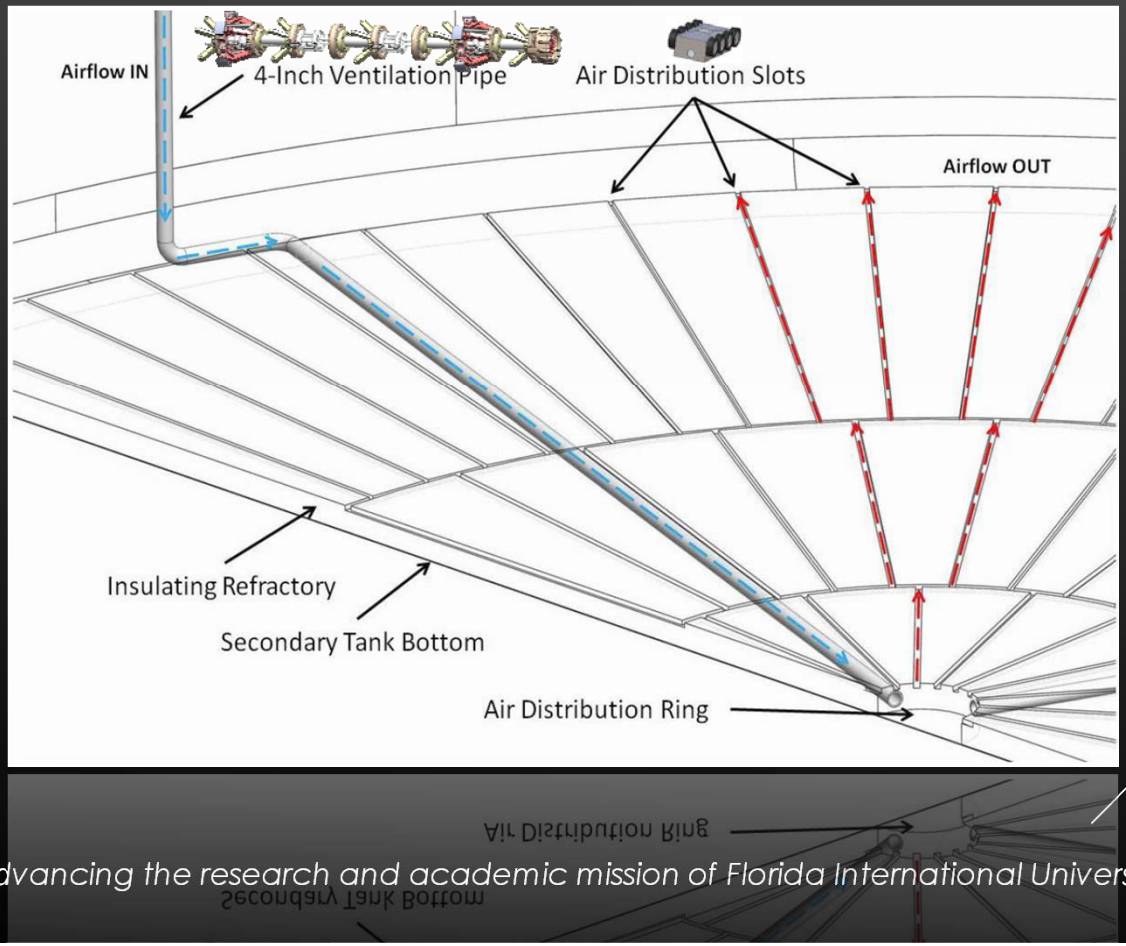
PROPOSED INSPECTION



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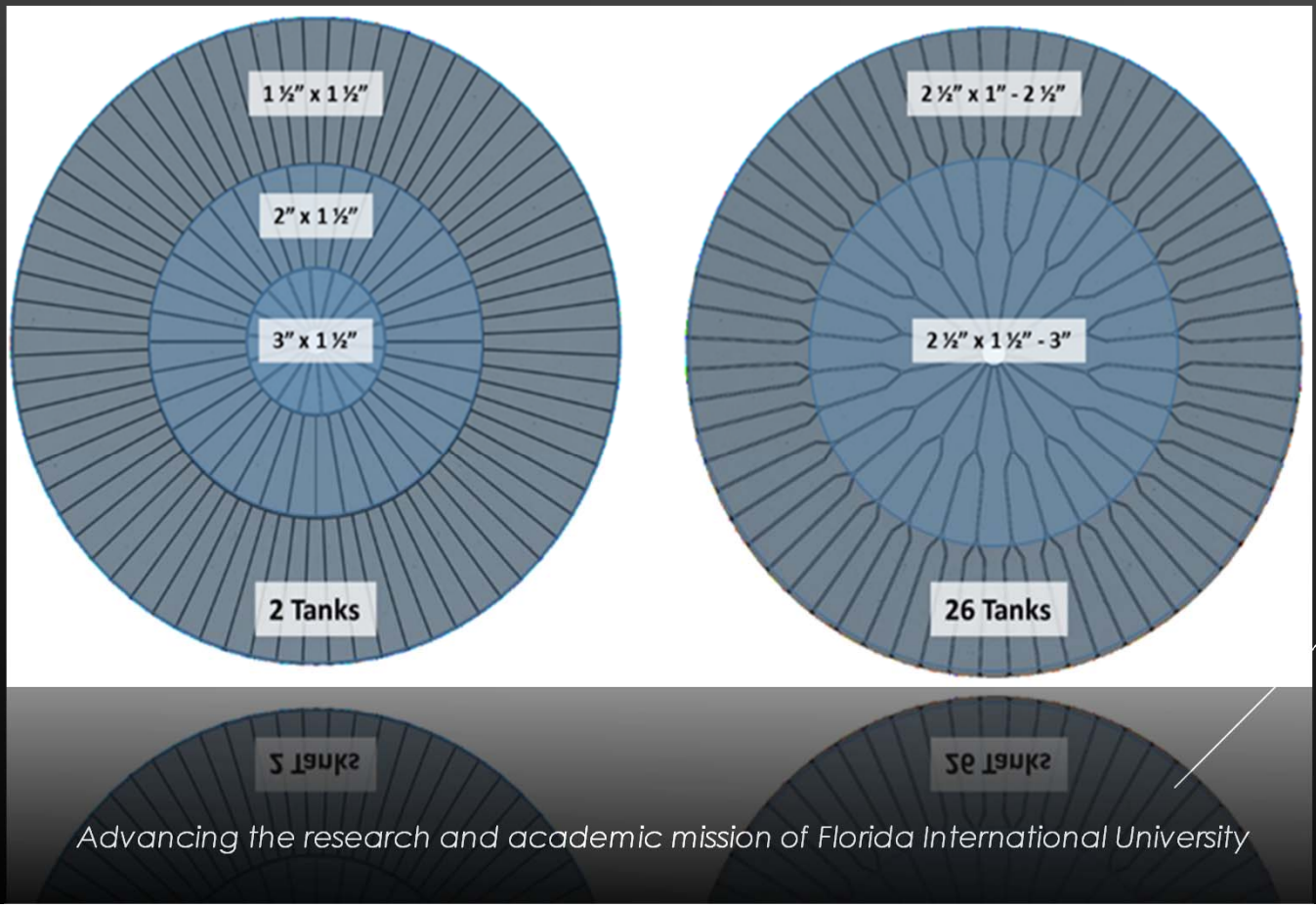
PROPOSED INSPECTION



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AIR SUPPLY LINE INSPECTION TOOL

OBJECTIVE: *To develop an inspection tool that crawls through the air supply pipe that leads to the central plenum of the primary tank of the DSTs at Hanford and provides video feedback*

DESIGN PARAMETERS:

- *Remote controlled*
- *Video feedback recorded for future analysis*
- *Radiation hardened (~80 rad/hr)*
- *High temperature environment (~170 ° F)*
- *To be used in pipes and fittings with 3" and 4" diameters*
- *Will need to turn through elbows, bends, and transitions*
- *Will need to crawl through vertical runs*

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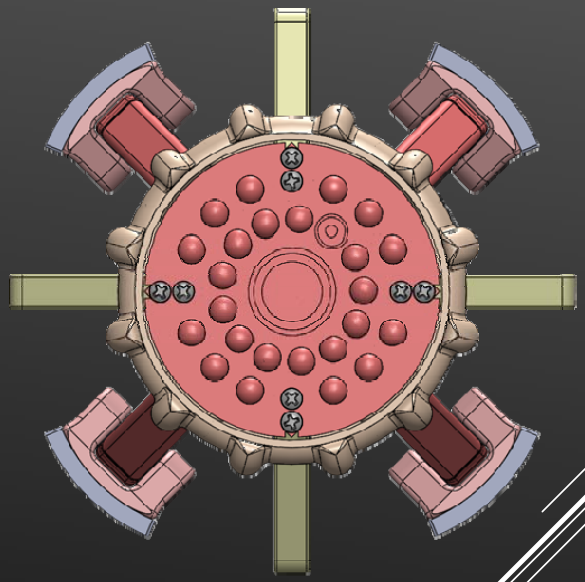
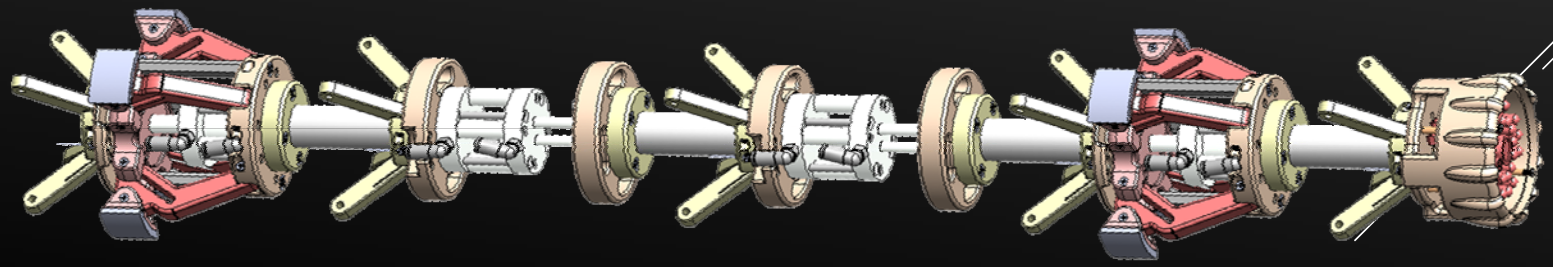
THE DESIGN

Pneumatic Actuators to emulate the contractions of the peristaltic movements

Movement does not require embedded electronics and electric actuators

Suitable for highly radioactive environments with potential exposure to flammable gases





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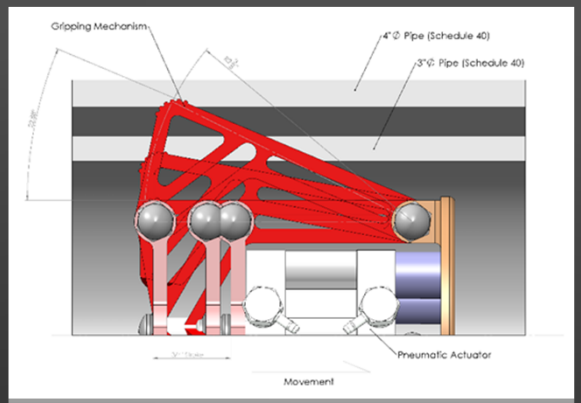
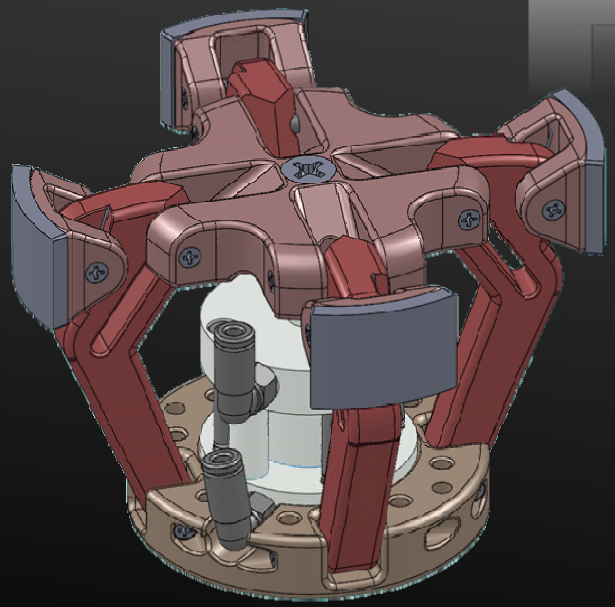
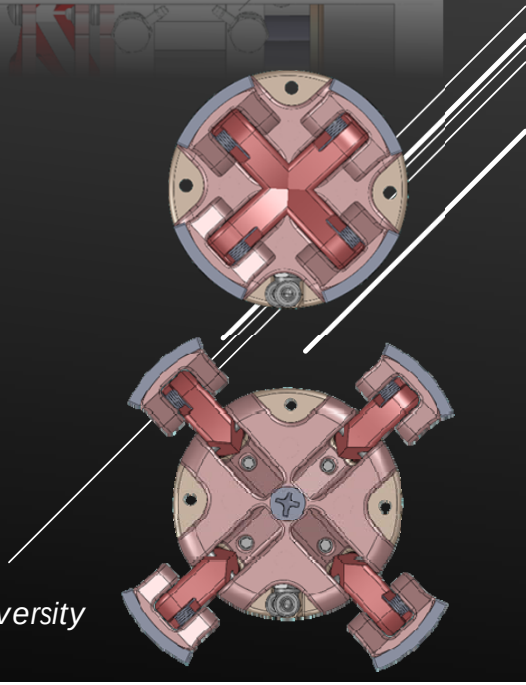
GRIPPER MODULE

Maximizing the strength of the gripper is a major factor in the design

Stronger grip would allow the device to carry additional modules, and to inspect longer pipelines







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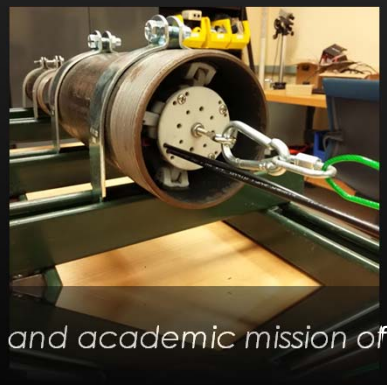
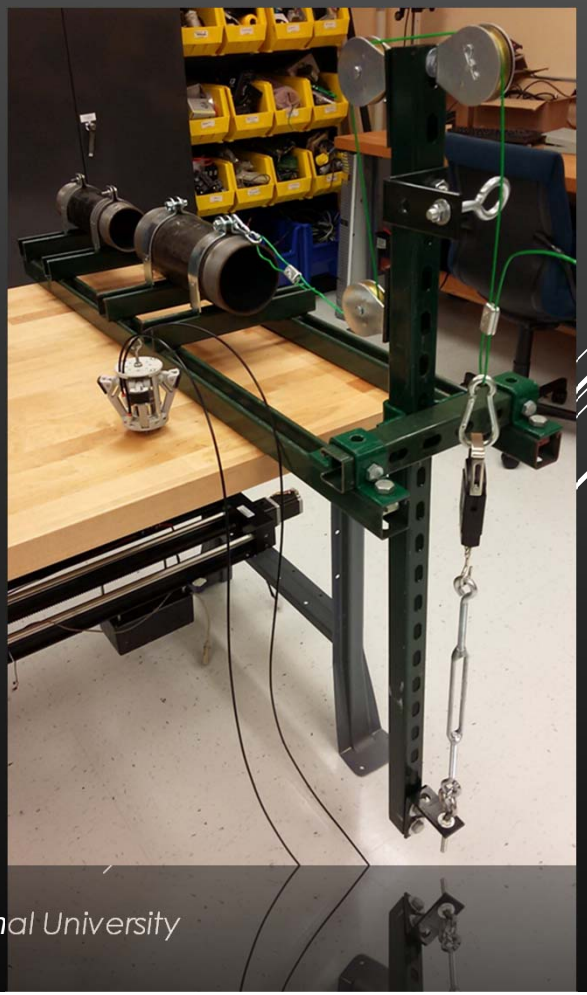
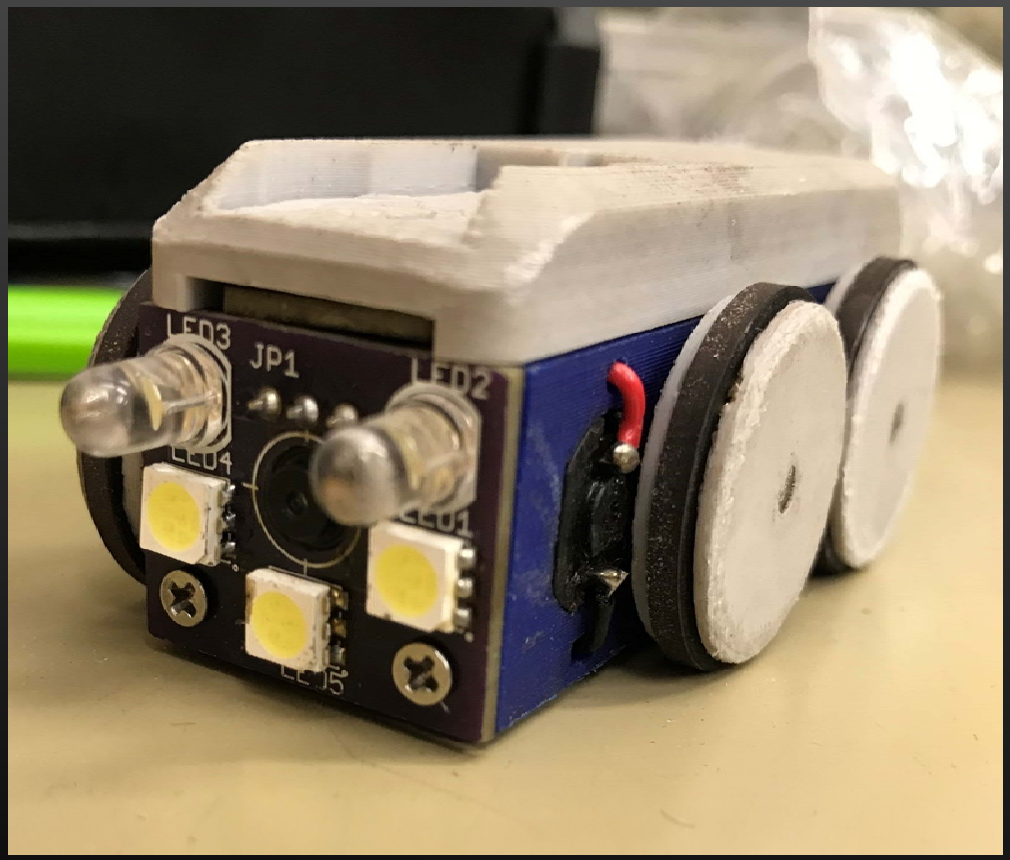
BENCH SCALE TESTBED

The current grippers are able to provide a maximum gripping force of ~40 lbs

This is also the maximum force with which the mover modules can propel the crawler in the forward direction






LED3
JP1
LED2
LED4
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LED5

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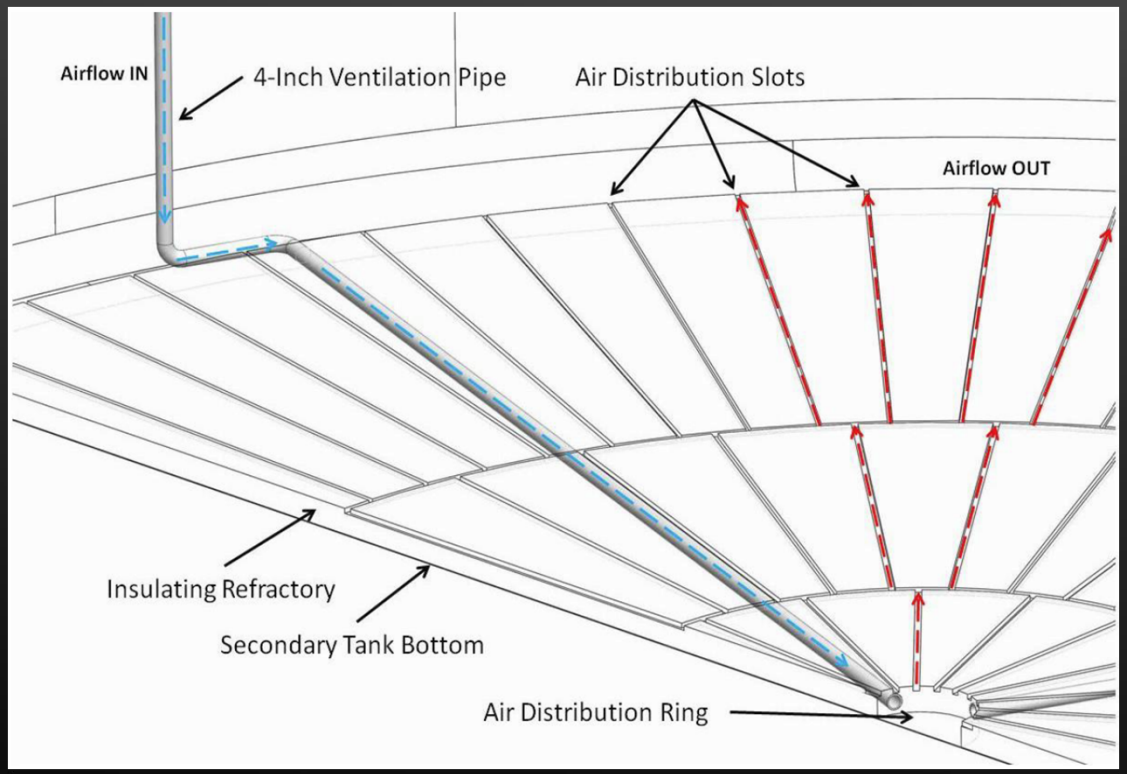

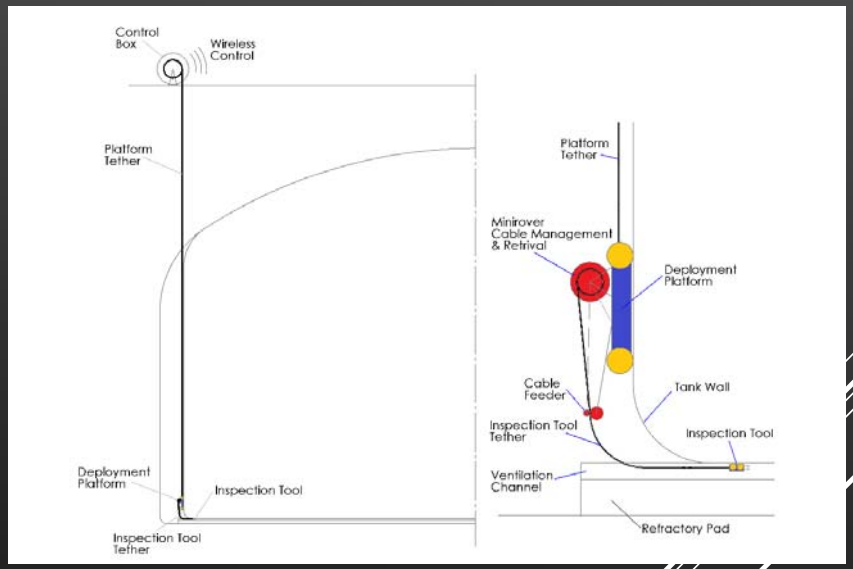

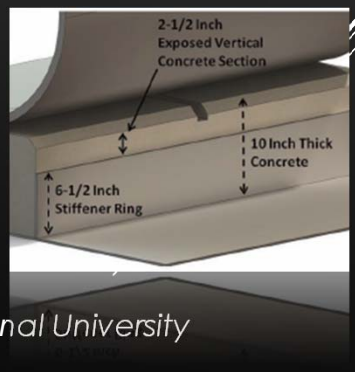

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REFRACTORY SLOT INSPECTION TOOL

OBJECTIVE: *To develop an inspection tool that navigates through the refractory pad air channels under the primary liners of the DST's at Hanford while providing live video feedback*

DESIGN PARAMETERS:

- *Travel through small cooling channels*
- *Remote controlled*
- *Inserted through a riser to the annulus floor*
- *Live video feedback*
- *Radiation hardened (~80 rad/hr)*
- *High temperature environment (~170 ° F)*
- *Must not subject the channel walls to pressures greater than 200 psi (the compression strength of the refractory material)*
- *Tethered*

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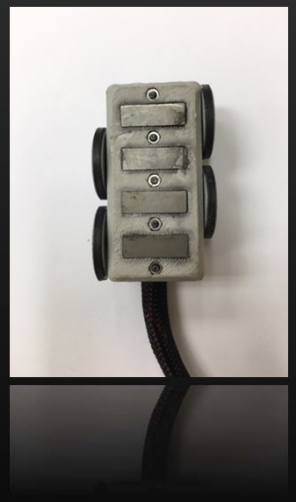
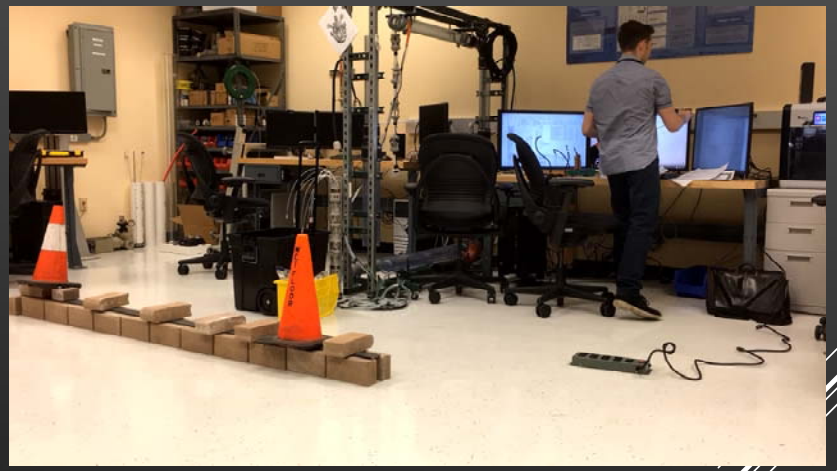
BENCH SCALE TESTING

Maximum Pull Force



- Device weight: 0.18 lb
- Average pull force: 4.75 lb
- Tests performed at: 5V
- Power/Weight ratio: 26
- Motor rated for 3-9 V



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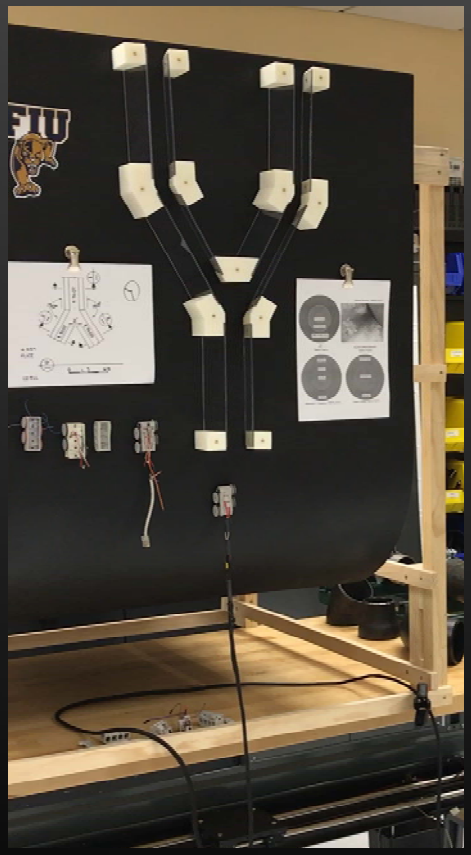
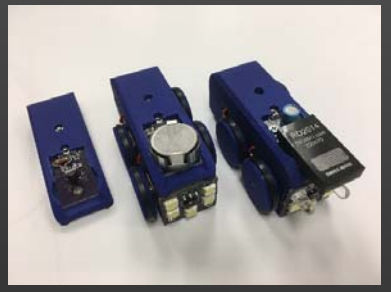
CURRENT PROTOTYPE





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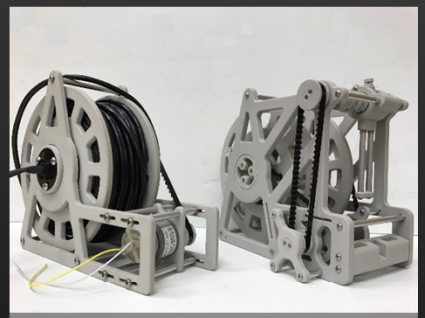
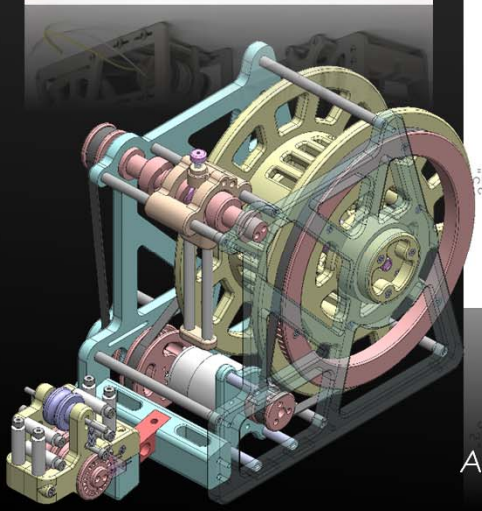
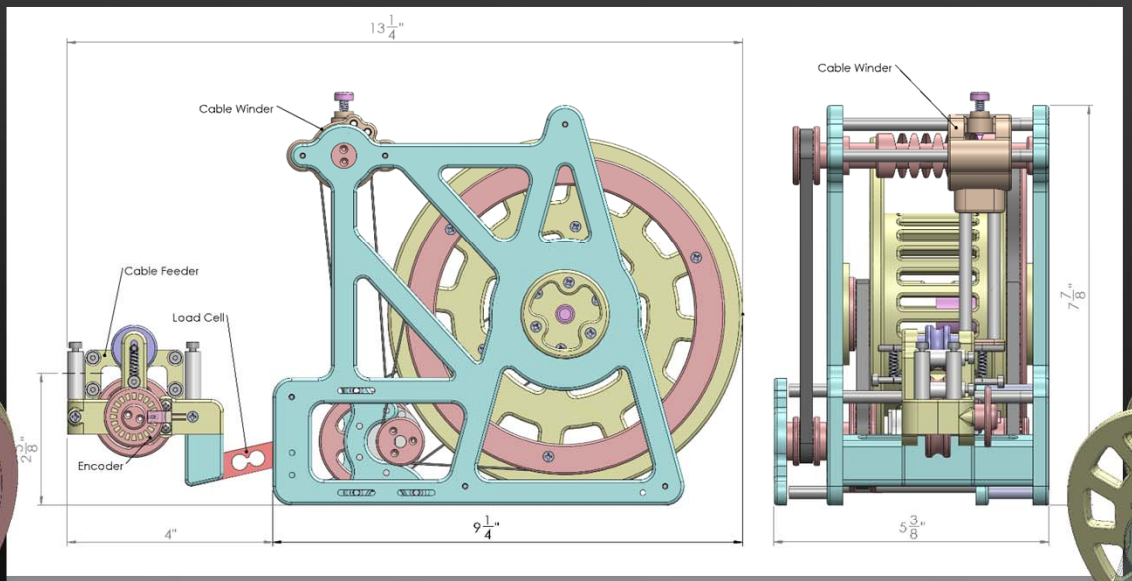
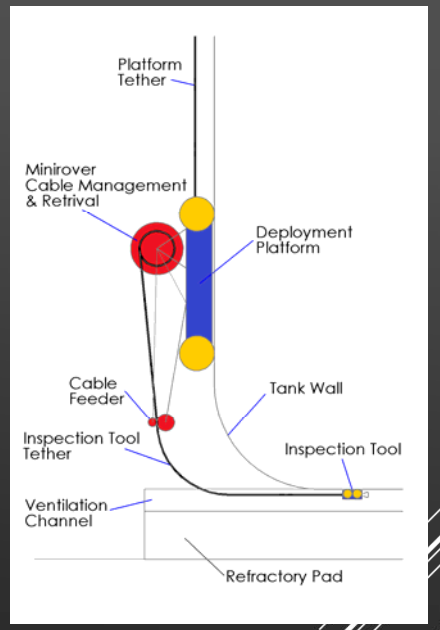
CABLE MANAGEMENT

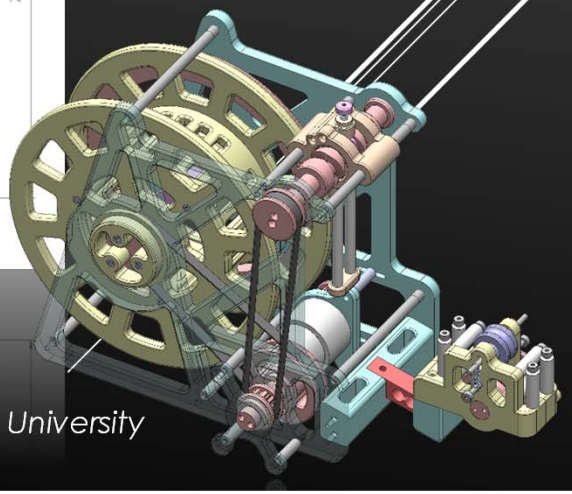
Goal: To design a system to let out/recover the tether of the rover with precision











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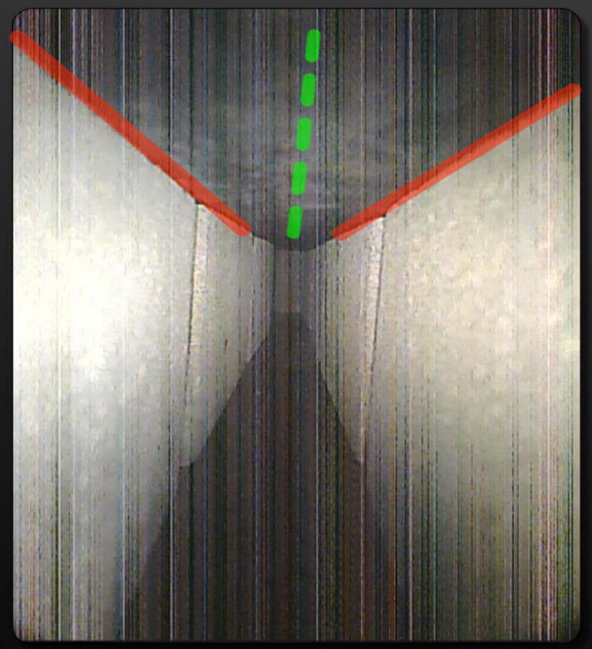
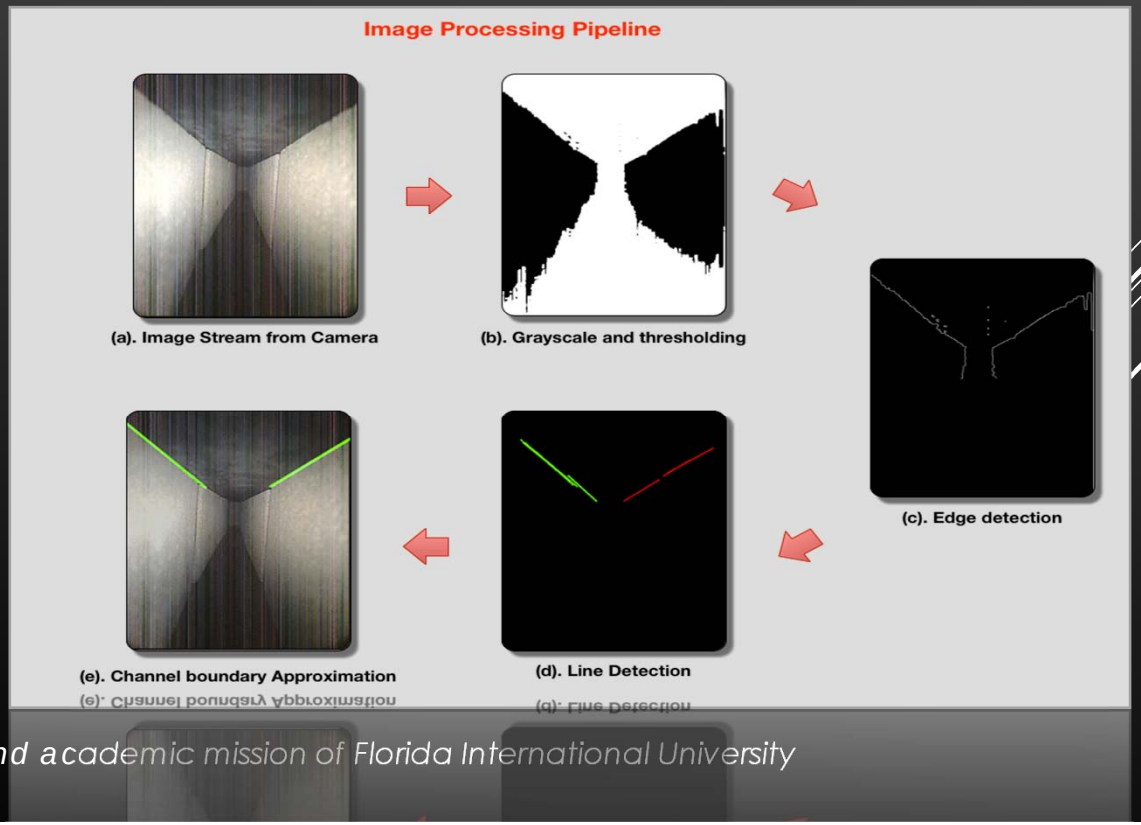
MOVING FORWARD SEMI-AUTONOMOUS DRIVING





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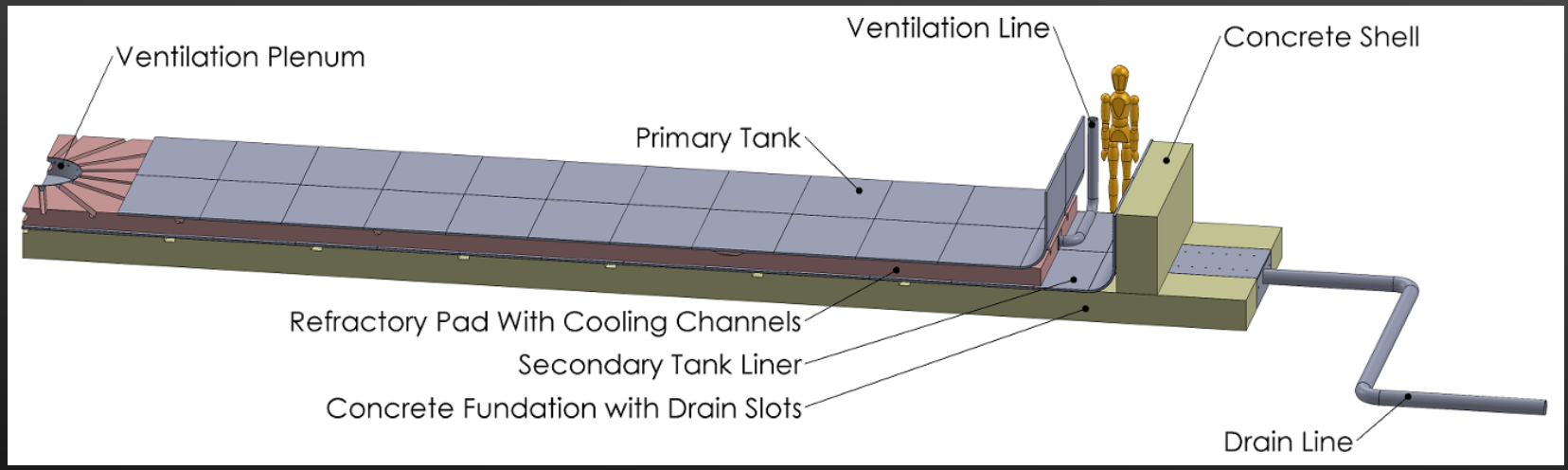
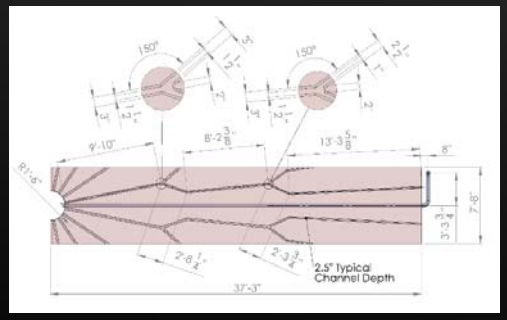
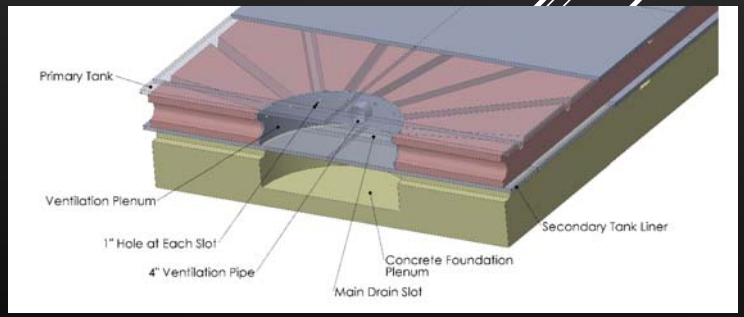
SECTIONAL FULL-SCALE MOCKUP







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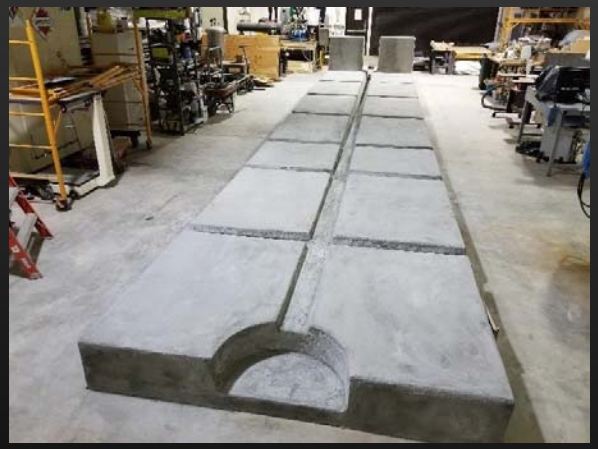
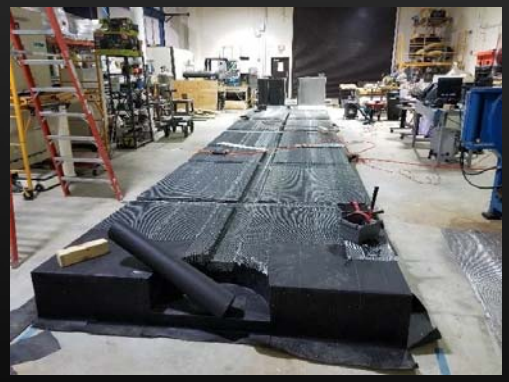
DRAIN SLOTS





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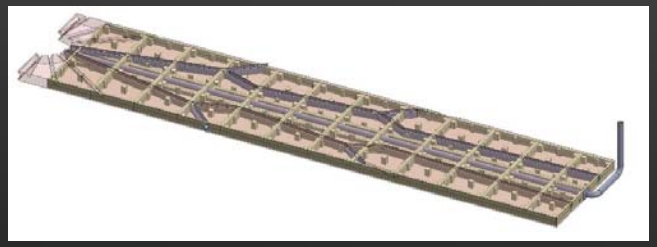
AIR SLOTS



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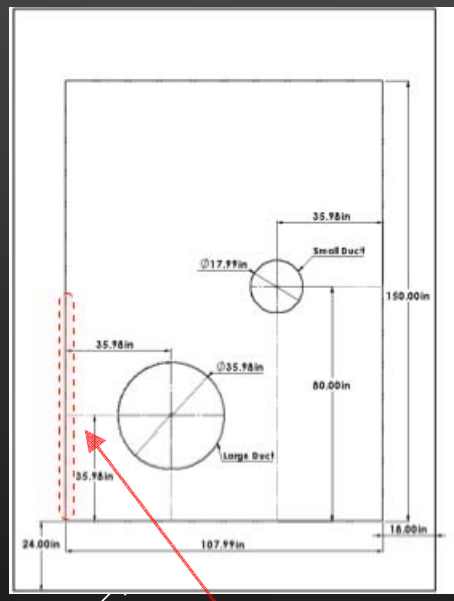
PIPE EXTERNAL CRAWLER

OBJECTIVE: *To develop an inspection tool that can navigate around the exterior of a 3 ft diameter pipe and provide video feedback*

DESIGN CHALLENGES:

- *Build up of gravel, sand and dust atop the 36" diameter duct*
- *Debris about 6-8 inches wide and 1 inch in height, runs the entire duct length*
- *25-30 mph wind with sudden gusts*
- *Duct is supported hanger belt and rod attached to the ceiling. Belt is 1/4 inch thick*



Area of interest

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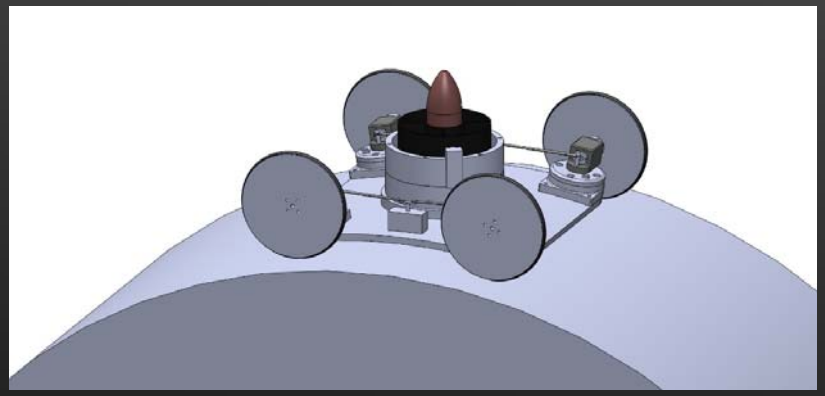
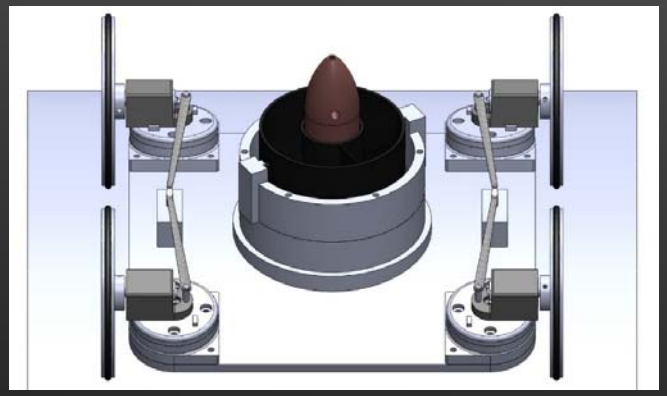
CONCEPTUAL DESIGN





Design Description

- Platform chassis is curved to match the curvature of the duct
- Uses 70mm ducted fan for propulsion
- Weight is ~ 1.5 lbs
- Mini linear actuators are used for changing the unit's orientation along/around the duct system
- Maximum normal force created is ~5.2 lbs, capable of navigating upside down

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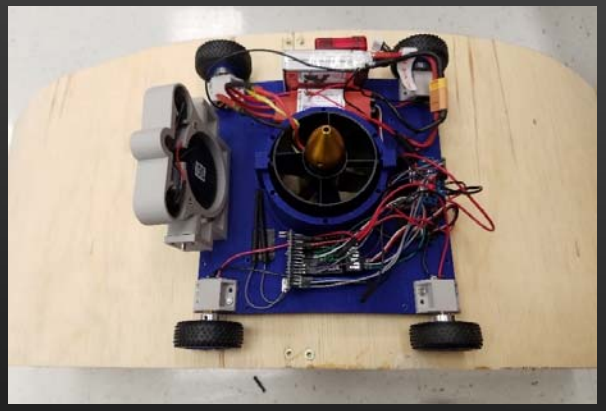
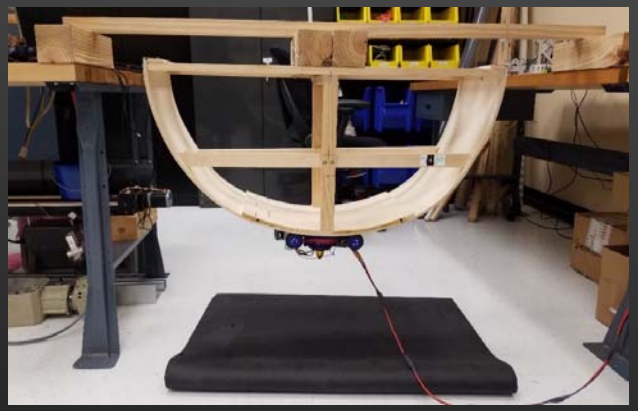
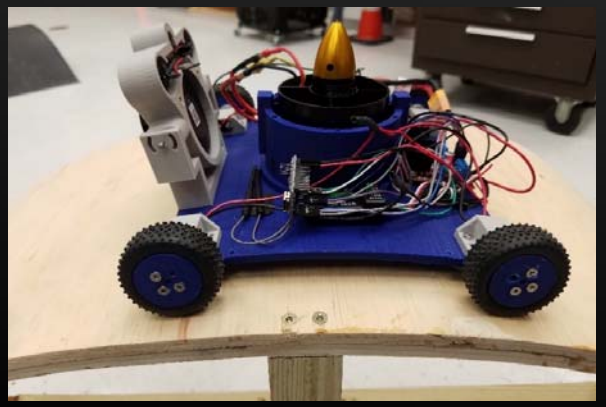
INITIAL PROTOTYPE







- 3D printed curved chassis with curvature that conforms to the duct geometry
- Fitted with both the IP camera and lighting source
- System operates at ~ 225W
- New platform structure made of composite material

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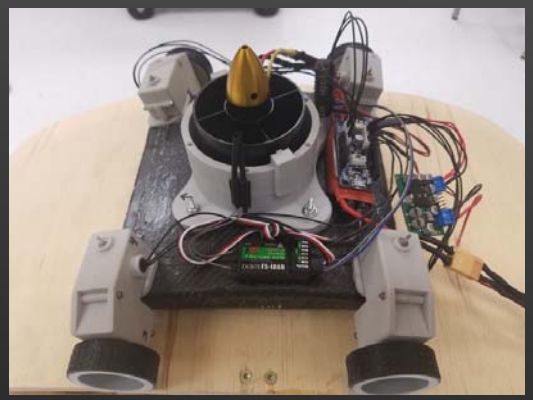
CURRENT PROTOTYPE



- Two DOF rover drive system for lateral and circumferential maneuver along and around the duct
- Curved chassis composed of carbon fiber material
- Tethered but can be modified for use with battery

MOVING FORWARD

Pneumatic Crawler

- Develop delivery mechanism for easy development
- Provide feedback of other inspection parameters (temperature, relative humidity, radiation, etc.)
- Redesign a radiation hardened version
- Scale the design for smaller pipe sizes

Rover

- Develop delivery mechanism for easy development
- Provide feedback of other inspection parameters (temperature, relative humidity, radiation, etc.)
- Redesign a radiation hardened version
- Autonomous deployment/maneuvering of inspection tool

Pipe External Crawler

- Remote control of the rover drive system
- Different propeller and impeller setups
- Camera and lighting integration

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HYBRID INSPECTION
SECONDARY LINER BOTTOM CORROSION